HELICOPTER SPRAY TRIALS WITH CARBARYL (XLR)

by

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I. Study Site Description

This study was conducted in San Luis Obispo County, California, at a site approximately 15 miles south of the city of San Luis Obispo. The site consisted of about 20 acres of rolling hills in a canyon and was representative of California live oak woodland. The flight line portion of the study was conducted in open grassland and the canopy work was done in a stand of live oaks approximately 1/2 mile away. Weather data including temperature, wind speed and direction, and relative humidity was gathered from two locations. At the first location, a Met One weather station was set up on a hill approximately 50 m above the flight line and due north. A Weather Measure system was used at the second location approximately 1 kilometer northwest of the flight line. Spray applications were made between 0600 and 1200 hours on March 5, 1982.

II. Formulation and Application of Carbaryl Sprays

Approximately 35 gal. of carbaryl XLR spray was prepared (2.3% active ingredient) and was transferred into the spray tank of the helicopter. A small amount of rhodamine B dye was added to the tank to facilitate visual detection of spray droplets. Carbaryl sprays were applied by a helicopter flying at a speed of 75-80 knots using 8004 nozzles with a boom pressure of 60 psi with all 54 nozzles in use.

III. Materials and Methods for Mass Fallout and Droplet Size Deposition at Flight Line

A sampling line consisting of 20 fallout stations at 20 foot intervals was located perpendicular to the existing wind direction and the helicopter flight line. Each fallout station consisted of an 18 x 17 inch piece of plastic-covered cardboard affixed to a wooden stake approximately 18 inches above ground level to avoid interference from vegetation. The sampling line was relatively level except for a shallow gully (approximately 6 feet deep) on the west side. This necessitated placing a fallout station at the bottom of the gully in addition to the one at the top.

Before the actual spray trials were run, a few passes had to be made to calibrate the spray equipment. For this purpose, a pad of 8 x 18 inch butcher paper (waxed side up) was attached to the board at each fallout station. After the spray pass was complete the top sheet of paper was observed for spray deposition and discarded. Once the spray equipment was calibrated, actual sampling was begun.

At each fallout station a 4 x 5 inch Kromekote card with a protective cardboard holder was secured to the board with push pins just prior to each spray application. A 10 x 14.5 inch (1 ft^2) plastic backed absorbent pad was also placed on certain of the fallout boards prior to each spray pass. When sprays were applied from an elevation of 50 feet, these pads were placed at the five center stations covering a width of 80 feet. For passes made from a 100 foot elevation, the pads were placed at Station 8 and at alternate stations in both directions to accommodate a swath of 200 feet. Kromekote cards and absorbent pads were collected 10 minutes after the spray pass. A longer collection interval was unnecessary because windy conditions caused the smallest droplets to be blown out of the monitoring area. The pads were then picked up, folded in on themselves, wrapped in aluminum foil and stored on ice. Kromekote cards were placed in the protective folders for transport.

IV. Materials and Methods for Monitoring Downwind Drift

Three monitoring stations were set up at distances of 0, 200, and 350 meters downwind of the flight line to measure drift. At each station, three high volume (40 cubic ft/min) air samplers were operated for a period of 20 minutes immediately following each application. The machines were covered with plastic bags until the final approach of the helicopter when the covers were removed and the machines turned on.

One of the samplers was equipped with a dual stage cascade impactor on top of an 8 x 10 inch glass fiber filter (GFF). Another sampler was mounted with a collection jar containing 125 ml of amberlite XAD-2 polystyrene divinylbenzene copolymer resin (Rohm and Hass). The final sampler had an 8 x 10 inch GFF as a sampling medium. Three Kromekote cards were also set up near the air sampler at each location to document the presence of spray droplets. Except for the Kromekote cards, all sampling media were packaged and placed on ice immediately after the 20 minute sampling period.

V. Chain of Custody

A chain of custody form was filled out for and accompanied each sample from the time it was collected until analytical results were completed. Included were location, sample number, companion number, time, date, and other relevant information.

VI. Results - Mass Fallout and Droplet Size Deposition at Flight Line

The initial day scheduled for the helicopter trial was characterized by gusty winds exceeding 10 mph. The trial was therefore delayed one day. Unfortunately, the second day had similar if not stronger winds and we had no other choice than to run the calibration.

The quantities of carbaryl deposited on 10 x 14.5 inch absorbent pads ranged from 145 to 1,760 μg for the spray applied from a 50 foot elevation (Fig. 1). Due to an oversight, only five absorbent pads were set out on the flight line and Figure 1 presents only a partial picture of mass deposition. However, the 21 Kromekote cards placed along the sampling line did produce a good sample of droplet distribution in the swath width. Presented in Figure 2 is the droplet deposition presented as the number of droplets collected at various distances in the swath width. The highly irregular swath width pattern reflects the abnormally high wind conditions. The droplet size distribution ranged from 76 to 740 μ in eight distinct size ranges (Figure 3, 50 ft altitude) with the highest proportion of droplets (27.5%) in the 148 to 207 μ diameter size range.

The 100 ft altitude spray was also carried out with an inadequate number of samples for proper analysis (Figure 4) but the swath characterization was definable using the Kromekote cards. The adverse wind conditions again caused a highly irregular pattern (Figure 5). Total droplet deposition was reduced by approximately 25% when compared to the 50 ft spray trial and a noticeable shift to larger droplet sizes was detected (Figure 3). The proportion of droplets in the desired size range for eradication (<200 μ diameter) was reduced from 41.72% for the 50 ft flight to 26.29% for the 100 ft flight.

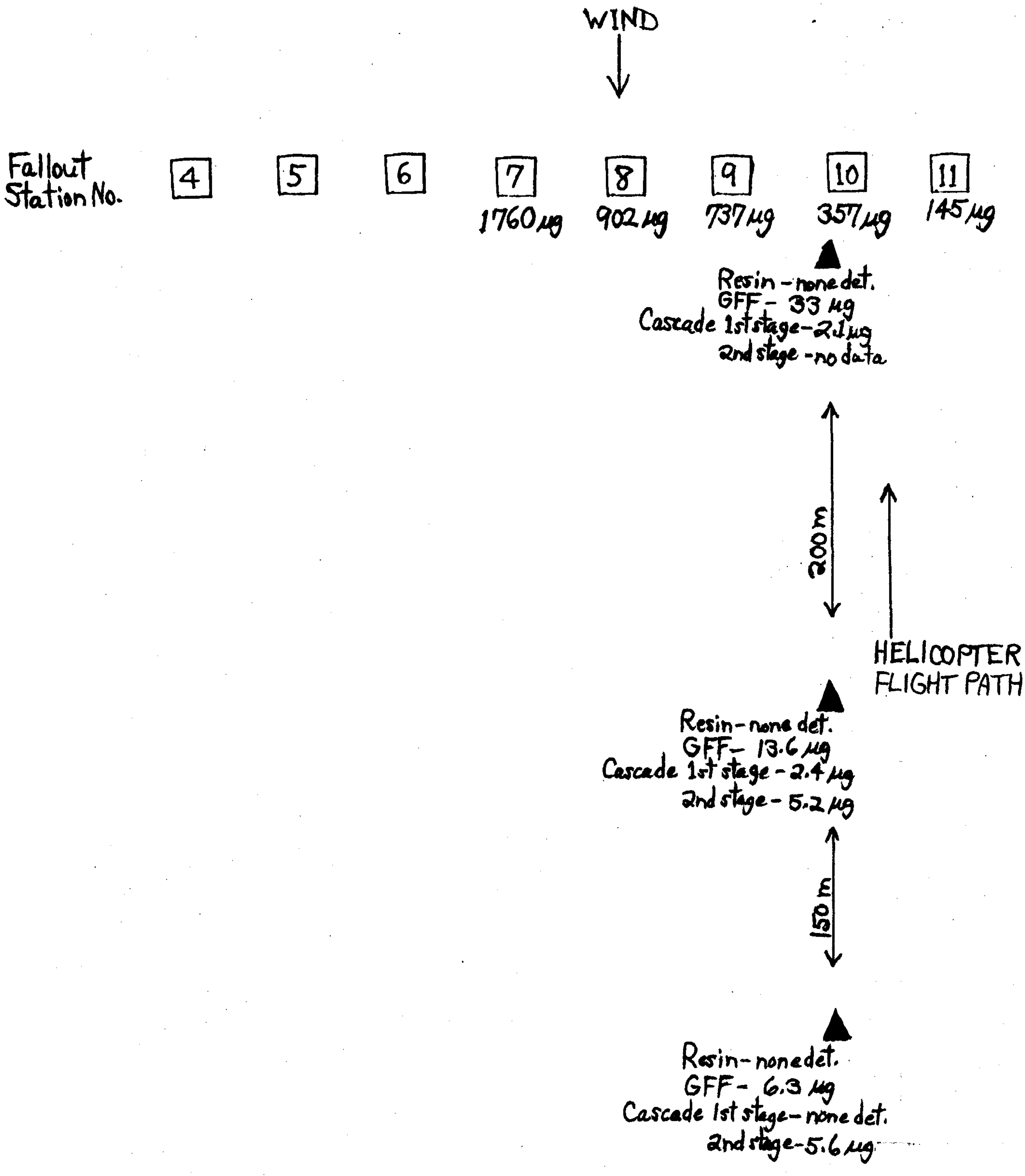

Figure 1. Mass deposition of carbaryl sprayed from a 50 ft. elevation onto fallout stations spaced 20 ft. apart and monitoring of down wind drift of spray using high-vol air samplers (▲).

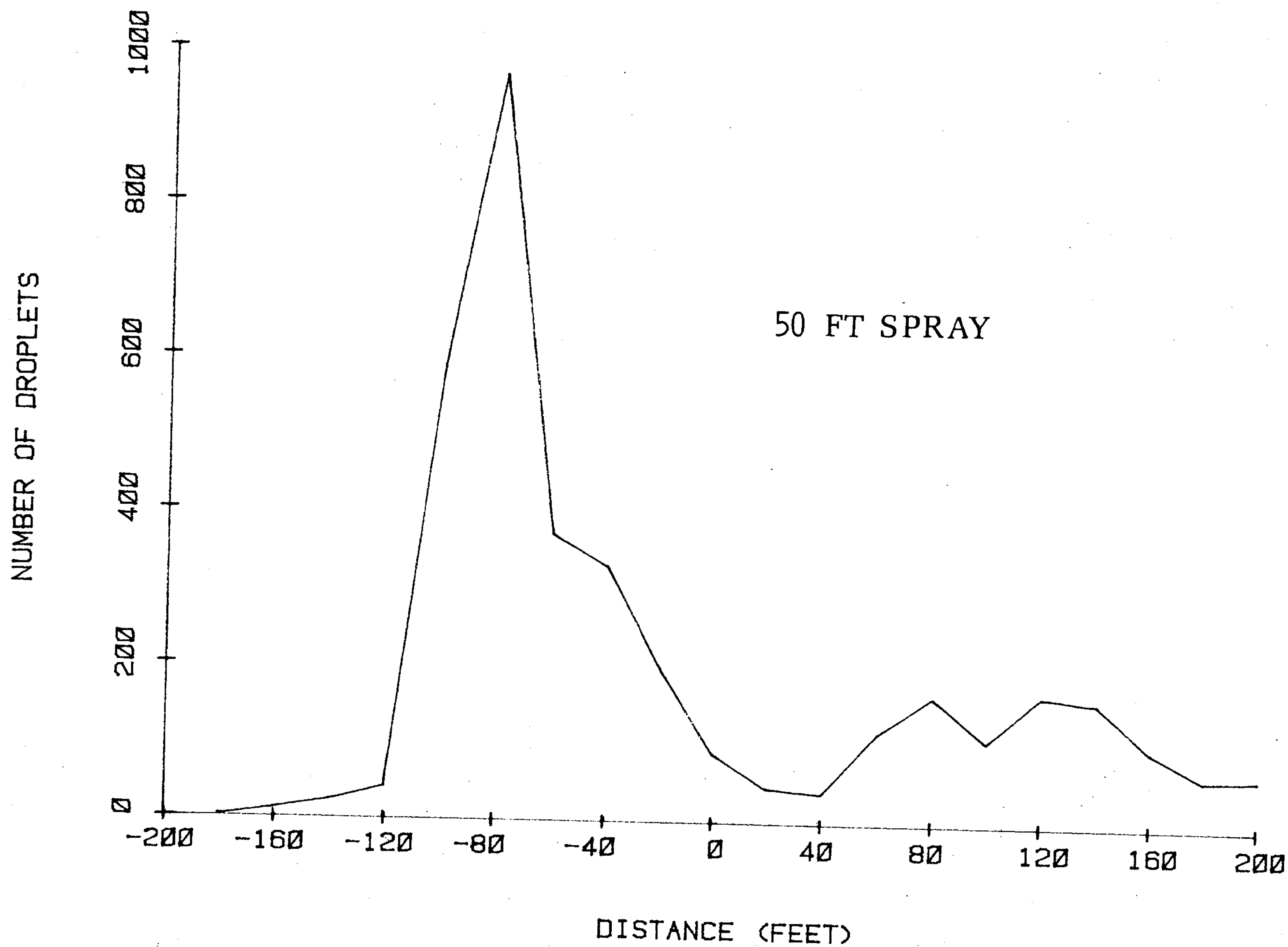

Figure 2. Deposition of carbaryl spray droplets on Kromekote cards at fallout stations located at various distances in the swath width. The fallout station at 0 feet was directly beneath the flight path of the helicopter.

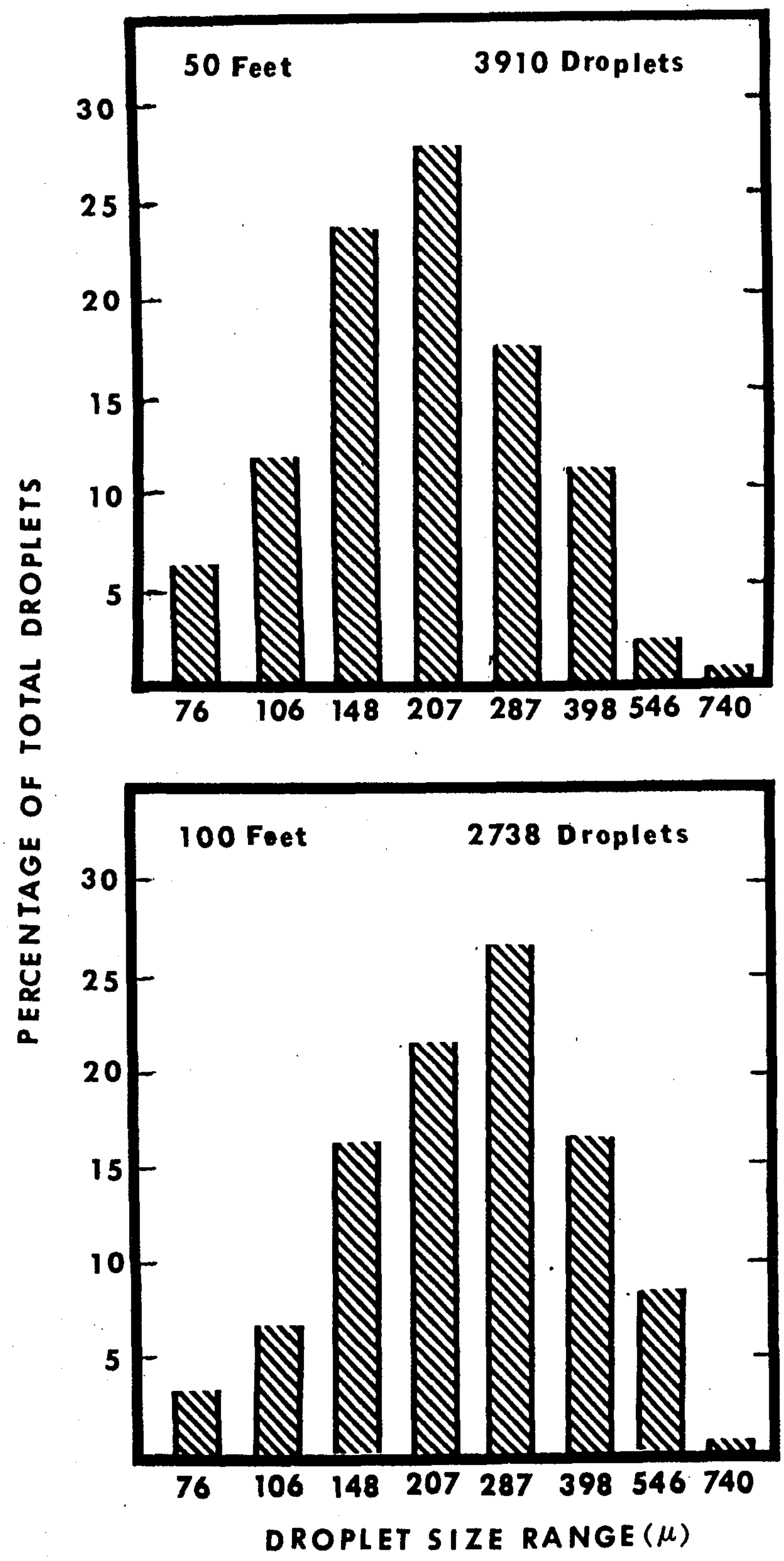

Figure 3. Percentages of carbaryl spray droplets in various size ranges after application from a 50 ft. or 100 ft. elevation. Total number of droplets was determined by adding all droplets on Kromekote cards placed at fallout stations on the flight line.

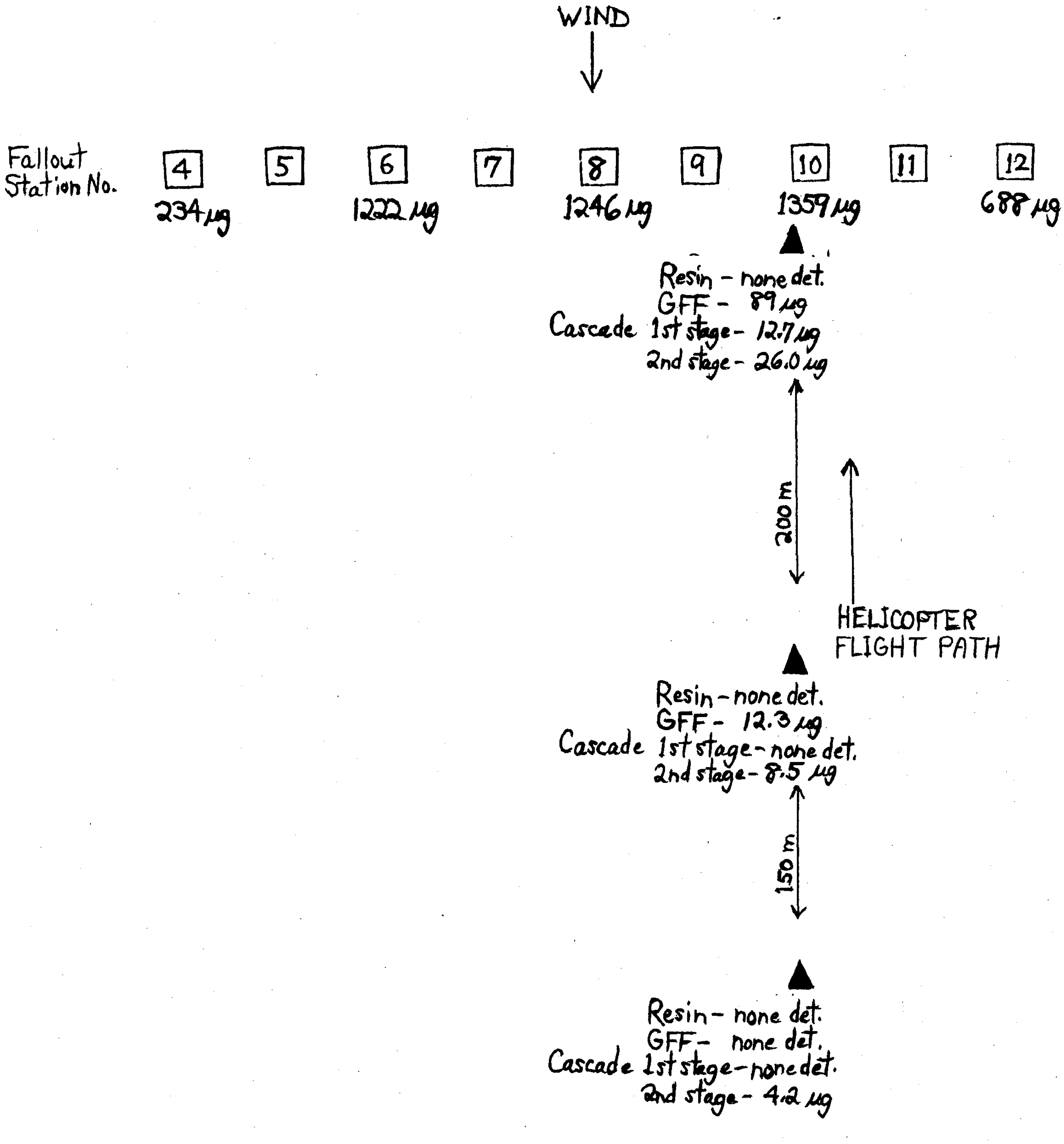

Figure 4. Mass deposition of carbaryl sprayed from a 100 ft. elevation onto fallout stations spaced 20 ft. apart and monitoring of downwind drift of spray using high-vol air samplers (▲).

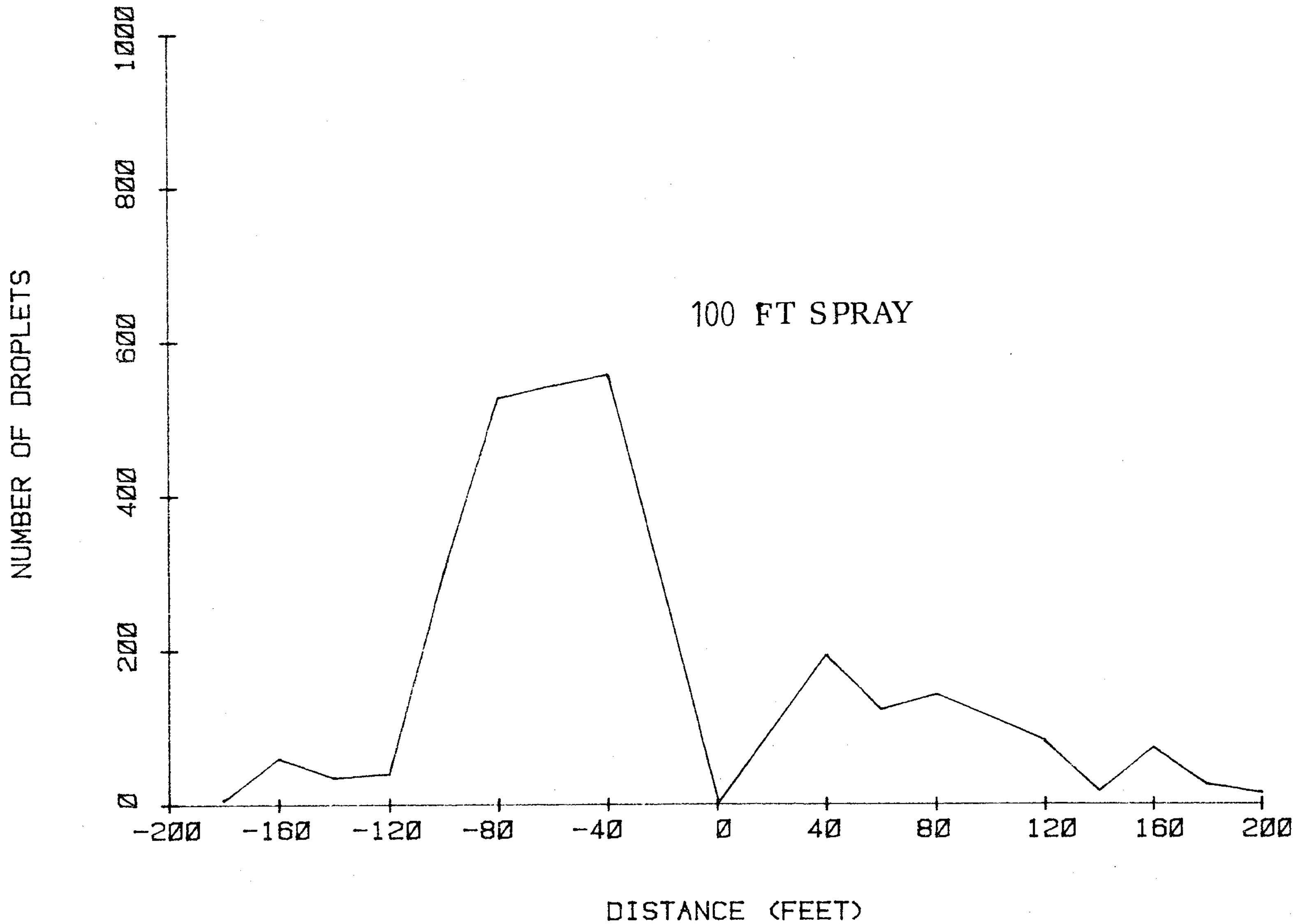

Figure 5. Deposition of carbaryl spray droplets on Kromekote cards at fallout stations located at various distances in the swath width. The fall-out station at 0 feet was directly beneath the flight path of the helicopter.

VII. Results - Monitoring Downwind Drift

Data are presented in Figure 1 for carbaryl collected with Hi-Vol air samplers following the application of carbaryl from the 50 foot elevation. As expected, the quantity of carbaryl collected on GFF was greatest at the flight line location and decreased as the distance from the flight line increased. Amounts collected on the first stage (particles 3.5 μ diameter or larger) of the cascade impactor ranged from 0 to 2.4 μg. The second stage, which collects particles 3.5 μ diameter or smaller (respirable fraction) contained from 0 to 5.6 μg carbaryl. No carbaryl was detected in any of the resin samples which would have collected volatile compounds.

When the spray was applied from a 100 foot elevation, the quantity of carbaryl collected on GFF again decreased as the distance from the flight line increased (Figure 4). Droplets 3.5 μ diameter or smaller (second stage) ranged from 4.2 to 26.0 μg and decreased with each increase in distance from the flight line. Again, no carbaryl was detected in any of the resin samples.

The total numbers and size ranges of droplets collected on Kromekote cards placed at downwind locations are presented in Table 1. Approximately six times more droplets were deposited on the cards after the 50 ft altitude trial than after the 100 ft trial. The large sizes of the droplets attest to the wind velocities present that day. Normally one would expect such large droplets to deposit in close proximity to the target area.

Table 1. Size ranges of carbaryl droplets collected on Kromekote cards located near high-vol air samplers at two locations down wind of the flight line.

Spray Elevation	Location of Sample Cards	Total droplets on 3 Cards	Percentage of droplets in each size (μ) range				
			148	207	287	398	546
50 feet	200 m downwind	58	-	10.3	55.2	31.0	3.5
	350 m downwind	5	-	-	100	-	-
100 feet	200 m downwind	9	11.1	22.2	66.7	-	-
	350 m downwind	1	-	100	-	-	-

VIII. Conclusions - Flight Line Monitoring

Even under adverse application conditions (high winds), the results indicate the desirability of low level application. Droplet deposition is increased and, more importantly, the proportion of the droplets in the desired size range (<200 μ diameter) is maximized (41.72% at 50 ft, 26.29% at 100 ft). No vapor phase carbaryl was detected by <u>any</u> air sampler. This result may be attributable to the windy conditions that quickly diluted vapor to undetectable levels or the short duration of the test flights or a combination of these circumstances.

A significant fraction of the droplets produced from sprays at both elevations were in the respirable size range (<3.5 μ diameter) and were detected 350 meters downwind of the sample line. Droplets in this size range have very little mass so a sizeable number of droplets must have been generated in order to detect them on the second stage of the cascade impactor.

IX. Materials and Methods for Canopy Penetration Study

Two coastal live oak trees, 45-50 feet tall and located approximately 1/4 mile apart, were selected for the canopy penetration study. Cardboard boxes (16 x 10 x 7 inches) were used as supports for sample collection materials in tree canopies. One 4 x 5 inch Kromekote card and one 6 x 6 inch piece of plastic-backed absorbent paper were stapled onto the top and each of the four sides of the boxes. The top and sides of the box were numbered 1-5 for later identification as illustrated in Figure 6. A piece of twine 2 feet long was attached to each end of the box to serve as a means of securing it in the tree.

A box was placed in each of three locations toward the central part of the trees (Figure 7); one was placed directly under the uppermost part of the canopy, one was placed approximately at mid-height, and the third box was placed in the lower quarter of the canopy, approximately 10-15 feet above ground. The boxes were oriented so that the top (side 5) was parallel to the ground and side 1 faced the direction from which the spray helicopter was to approach. In order to prevent contamination from drift, the boxes were covered with polyethylene bags until the spray was to be applied. One tree was designated to be sprayed from 50 feet above the tree line and the other from 100 feet.

Spraying was begun when the helicopter was approximately 25 yards from a tree and continued 25 yards past the tree. Boxes were removed from the tree within 15 minutes after spraying was completed and the cards and absorbent

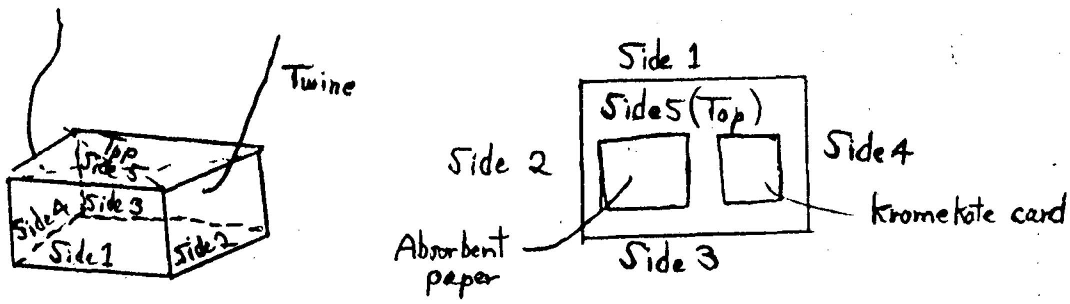

Figure 6

Figure 6-7. Sampling materials for canopy penetration study. 6, cardboard box to which Kromekote cards and absorbent pads were attached. 7, approximate location of boxes representing upper canopy, mid-height and lower canopy in a 50 ft. tall live oak tree.

paper were removed, labeled, and stored immediately thereafter.

Air beneath the canopy was sampled using a split system Low-Vol air sampling instrument designed to obtain replicate samples for a spray pass. Samplers were calibrated to draw 15 liters of air per minute through the resin tubes. Separate pairs of tubes were used for a 15 minute pre-spray sample, a 1 minute spray sample, and a 15 minute post-spray sample.

Leaf samples were collected from the tree sprayed from the 50 foot elevation. Samples consisting of 35 leaves were taken 30 minutes before and immediately after the carbaryl spray from within a 5 foot radius of the box placed at mid-height in the tree. A pair of pruning shears was rinsed with methanol and then used to clip off leaves from the terminal 6 inches of small branches in the canopy; the leaves were dropped into screw cap sample jars fitted with teflon seals and kept on ice until they were analyzed.

X. Results - Canopy Penetration Study

The following results relate only to the spray applied from 50 feet above the tree line; no carbaryl was detected in samples from the tree sprayed from 100 feet above the tree line.

Mass deposition of carbaryl on absorbent pads varied with the side of the box on which the pad was located and with the height at which the box was located in the tree (Figure 8). At each of the three height locations in the tree, the largest quantity of carbaryl (28-120 μg) always occurred on side 5 (top) which was oriented parallel to the ground. The second largest

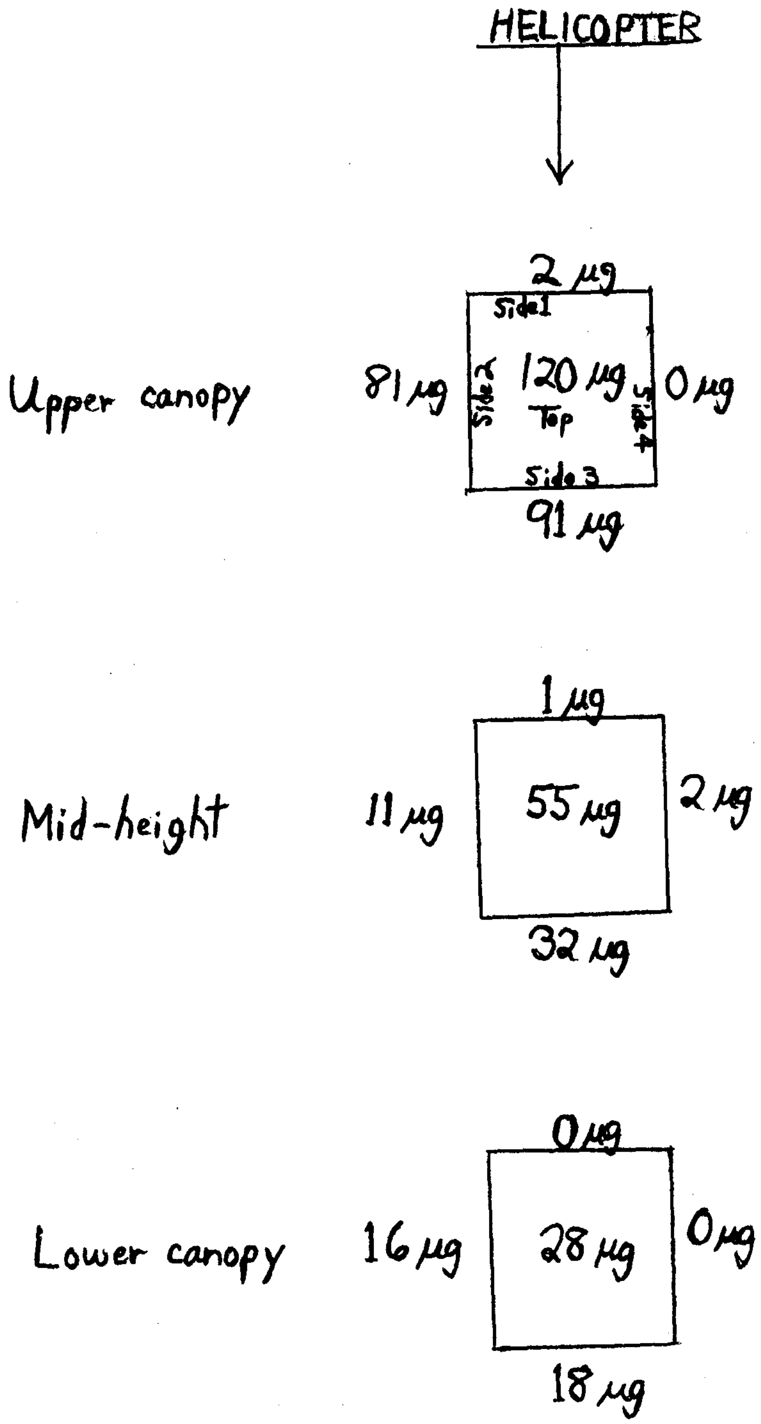

Figure 8. Mass deposition of carbaryl sprayed from 50 ft. above tree top level onto absorbent pads supported on cardboard boxes located at three heights in a mature live oak tree.

deposits were collected on side 2 or 3 (11-91 μg) with extremely small amounts (0-2 μg) on sides 1 or 4. A comparison of carbaryl concentrations on side 5 of each box shows a reduction of about 50% at each succeeding level below the upper canopy. It should be noted that the mass values represent total deposition on a 36 in.^{2} surface and the highest value (120 μg) near the top of the canopy calculates out to a mass deposition of 0.51 μg/cm^2 of surface.

Both the total number of droplets and size range of droplets collected varied with height in the canopy (Table 2). The top portion of the canopy collected the greatest proportion of droplets (1014) averaging 1.31 droplets per cm^2 for all 5 sides of the monitoring cube. The maximum droplet deposition (3.21 droplets/cm^2) occurred on the top side of the monitoring cube. Forty-three percent of these droplets were within an efficacious size range, 76 to 207 μ in diameter. The foliage present at the top of the tree was effective in minimizing droplets penetrating the canopy as documented by the mid-height and lower canopy monitoring stations. The mid-height station received almost a factor of 10 fewer droplets which were of a much larger size range and only 0.6% of these droplets were in the 76 to 207 μ size range. The lower canopy monitoring station collected only 59 total droplets and 66.1% of these were extremely large, greater than .398 millimeters in diameter.

No carbaryl was detected in resin tubes from Low-Vols used to sample air beneath the tree canopy.

Table 2. Droplet size ranges of carbaryl sprayed from 50 ft above tree top level onto Kromekote cards supported on cardboard boxes placed at three heights in a mature live oak tree

Location of box	Which Side of box	Total No. Droplets	No. Droplets per cm^2	Percentage of droplets in each size(μ) range 76	106	148	207	287	398	546	740
Upper canopy	1	0	0.00	-	-	-	-	-	-	-	-
	2	315	2.44	3.8	7.9	18.4	30.8	20.9	17.1	0.6	0.6
	3	284	2.20	6.3	27.5	29.6	31.7	4.6	0.3	-	-
	4	1	0.01	-	-	-	100	-	-	-	-
	5	414	3.21	6.3	10.4	24.1	22.7	24.2	12.1	0.2	-
	Combined	1014		5.5	14.4	23.9	27.7	17.7	10.3	0.3	0.2
Mid-height	1	0	0.00	-	-	-	-	-	-	-	-
	2	9	0.07	-	-	-	-	55.5	44.5	-	-
	3	63	0.49	-	-	1.6	26.9	20.6	42.8	7.9	-
	4	0	0.00	-	-	-	-	-	-	-	-
	5	95	0.74	-	-	-	15.7	34.6	49.7	-	-
	Combined	167		-	-	0.6	19.1	30.6	46.7	3.0	-
Lower canopy	1	1	0.01	-	-	-	100	-	-	-	-
	2	19	0.17	-	-	-	-	15.8	68.4	15.8	-
	3	7	0.15	-	-	-	14.3	57.1	68.4	15.8	-
	4	2	0.01	-	-	-	100	-	-	-	-
	5	30	0.23	-	-	-	6.7	23.3	56.7	10.0	1.7
	Combined	59	-	-	-	-	10.2	23.7	54.2	10.2	1.7

A total of 70 μg of dislodgeable carbaryl was present in leaves collected in the vicinity of the mid-height canopy location. The concentration of carbaryl was calculated to be o.3 $\mu g/cm^2$ (15 ppm, wt deposition/fresh wt leaf) based on a total leaf area of 233.2 cm^2. This was comparable to the o.51 $\mu g/cm^2$ deposition collected on the top surface of the upper canopy monitoring station. A second sample of leaves was also collected in early May from the same tree using the same methods. The fresh weight and surface area of the leaves were measured and used to calculate the density of the leaves as being 20 mg/cm^2.

XI. Conclusions - Canopy Penetration Study

The tests were conducted under adverse wind conditions (>10 mph). The 50 ft penetration study provided acceptable (efficacious) coverage only at the top of the canopy and on three sides of the monitoring cube (maximum values: mass deposition 0.51 $\mu g/cm^2$; 3.21 droplets/cm^2; 40.8% of droplets <207 μ in diameter). Both mass deposition and the number of droplets decreased to unacceptable levels at mid-canopy and lower canopy. Only a few very large droplets (207 to 740 μ diameter) managed to penetrate to these monitoring sites.

All samples taken for the 100 ft test were negative despite the fact that the helicopter flew directly over the test tree. One can only surmise that high gusts of wind caused droplets to be blown downwind beyond the tree.